

Application of Stirling Cycle Generators in Production Operations

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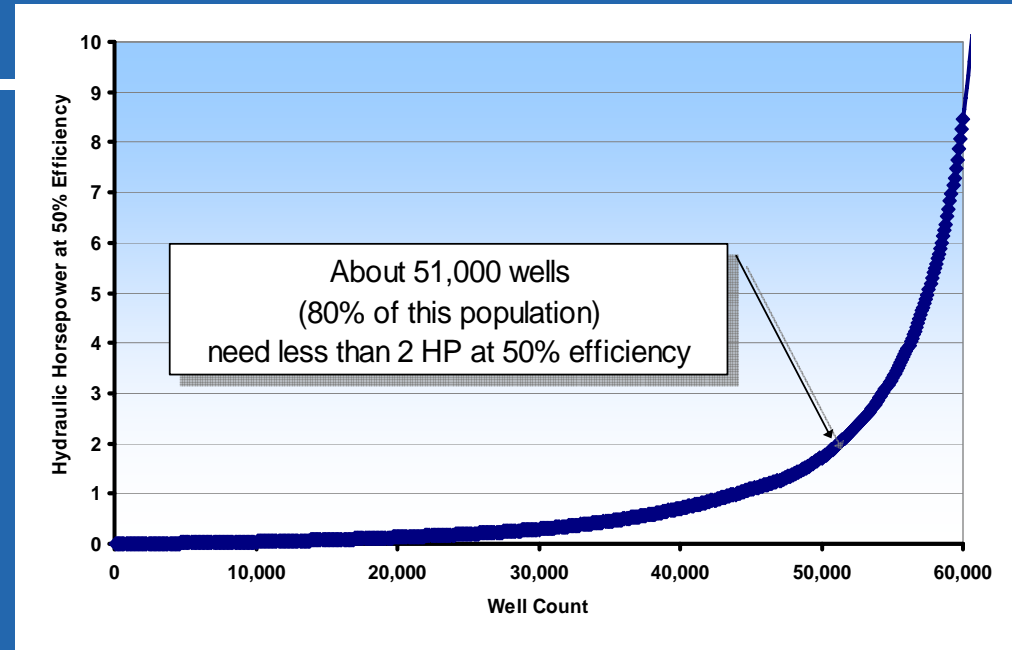
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Revision: 6/3/2008 Dotson

Why: Future Gas Well Deliquification

- Gas wells can be made more productive lifting very low liquid rates.. generally less than 20 BPD.
- There are a lot (~50,000) of deep gas wells that could benefit from less than 2 HP of lift .. but remote and has to be low cost.
- An inexpensive, low maintenance, “green” source of remote power < 5HP will be needed.



Outline

Alternatives & Selection

*Stirling Cycle: Description,
Characteristics*

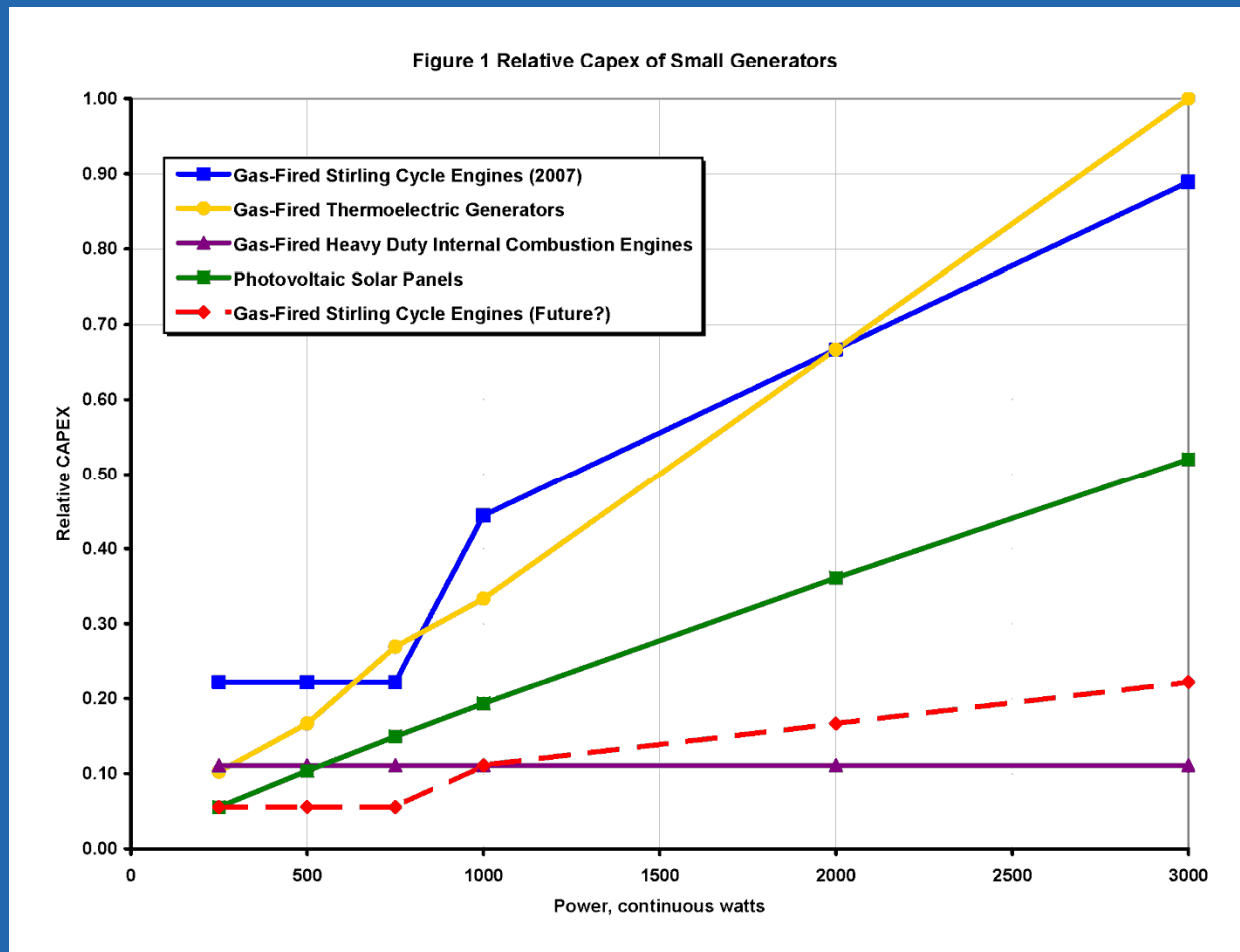
Sucker Rod Pump Application at RMOTC

SCADA Application at Wamsutter

Conclusions

Alternatives & Selection Criteria

- Reliability
- Capital Expenditure
- Operations & Maintenance Cost (O&M)
- Fuel Cost



Selection of Stirling Cycle

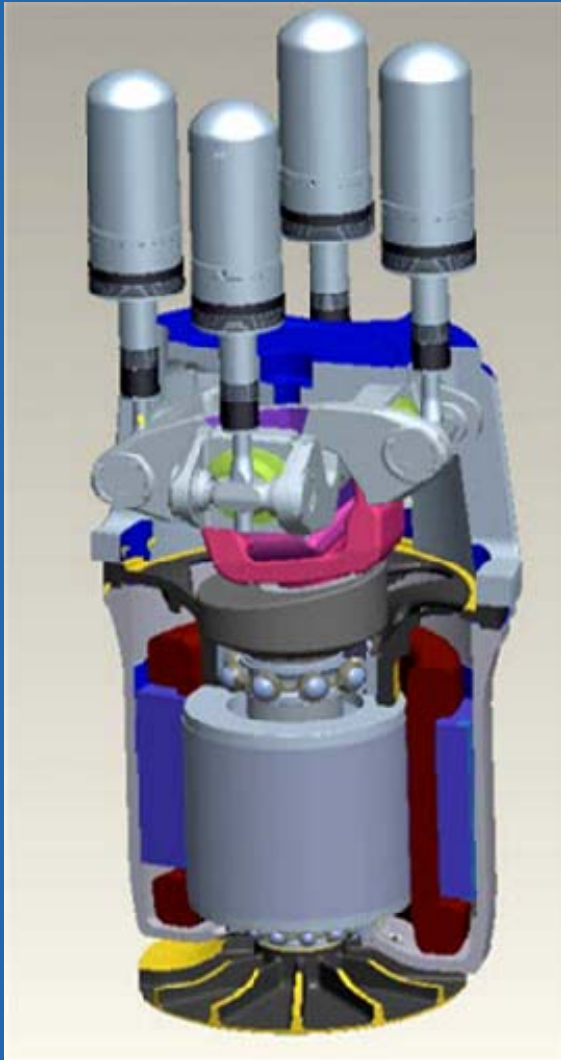
- For gas wells, gas fuel is almost always available without transport.
- Large market developing for microCHP.
- Stirling Cycle has maintenance advantages; emerging technology.



BASEMENT PORTRAIT:
Bernard Malin of Braintree,
Mass., and his electricity-
generating furnace.

MELANIE STETSON FREEMAN – STAFF
Christian Science Monitor Article Nov. 14, 2006

Stirling Cycle Engine



Stirling external combustion engine

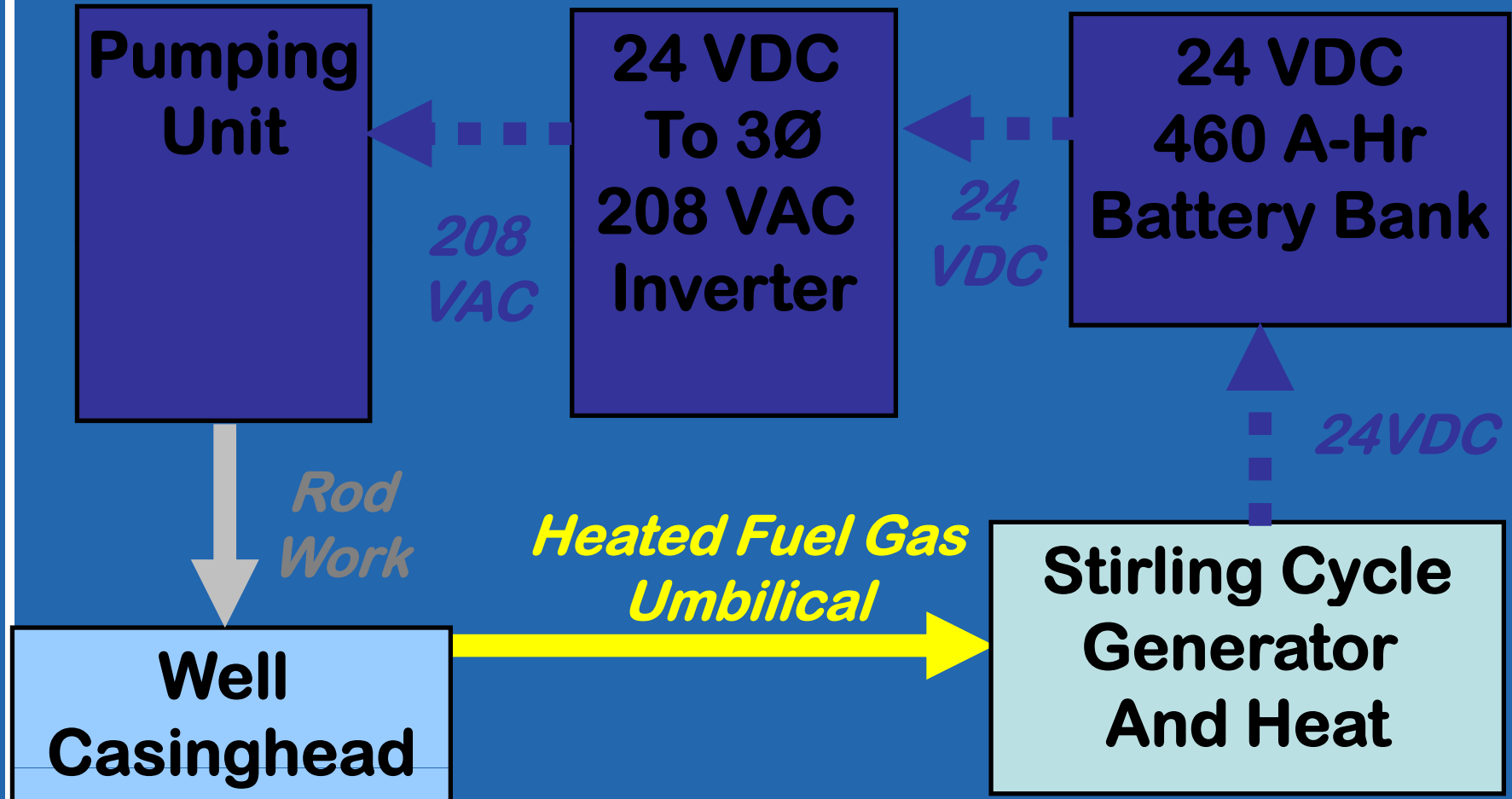
- Simple concept with 200 years of history
- Pistons are powered by nitrogen gas inside a sealed chamber
- The gas expands and contracts as it is heated and cooled
- A wobble yoke transfers the pistons linear motion into rotational motion to generate electricity
- Cooling water is heated during this process and this is available for other uses (similar to a cogen)

Direct Current System

- BP trials based on existing natural gas-fired DC system:
 - 24 VDC, 800W generator with fully automated battery charging
 - Gas consumption is .7 cubic meter per hour = 25 cubic feet per hour
 - Electrical efficiency is 11%.
 - If waste heat can be used, total efficiency is 90% (79% thermal recovery)
- Anticipate new DC gas model to be developed with longer maintenance interval.

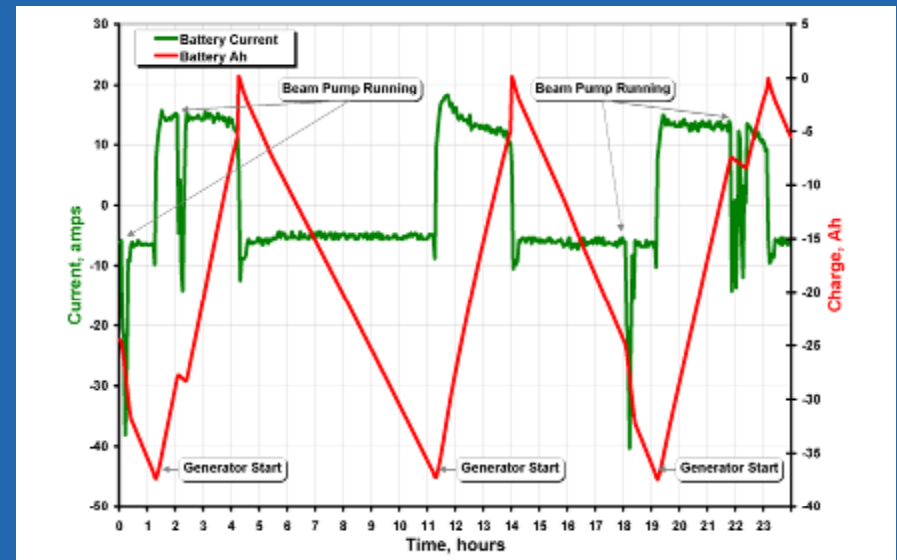


System: DC Buffer Arrangement

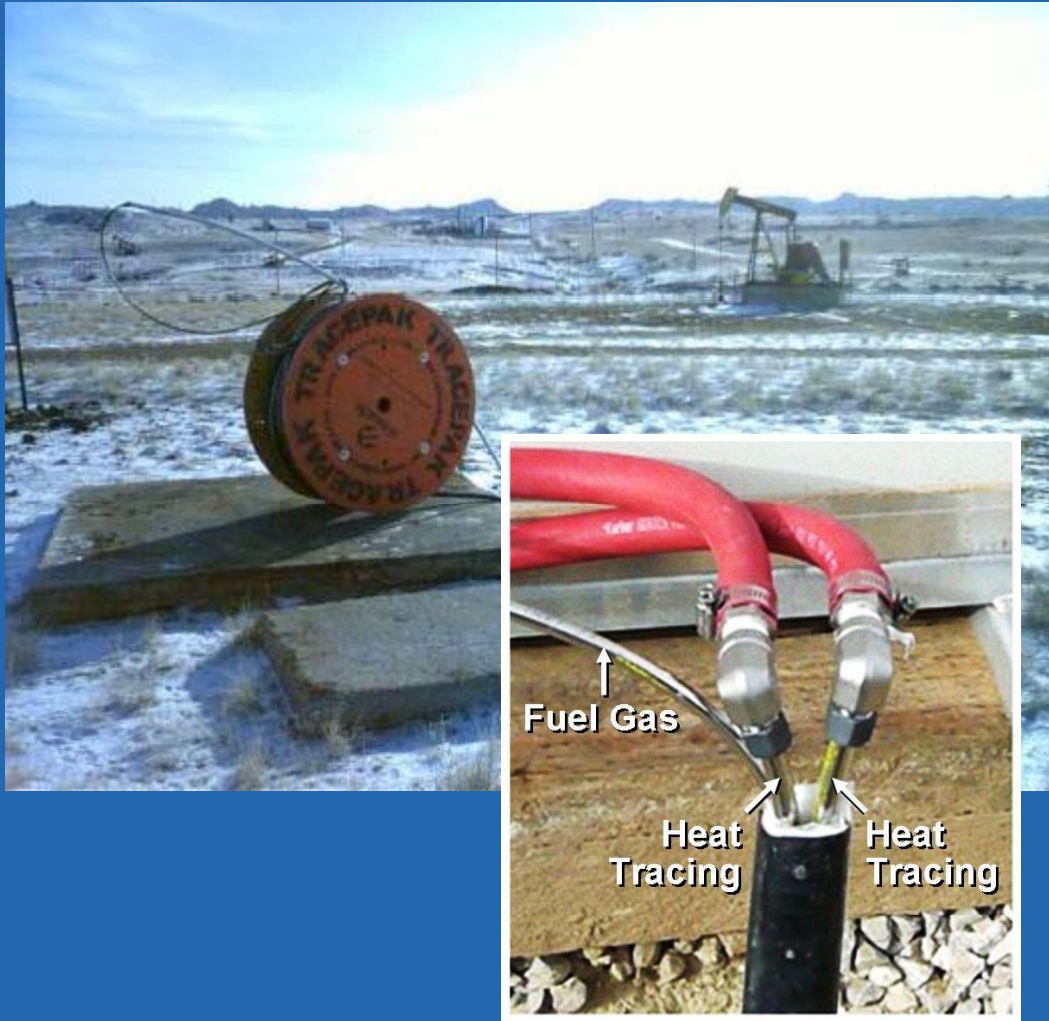


DC Buffer Concept

- DC Generator automatically charges the battery bank at 800W (19kWh / day).
- Battery bank is sized to supply additional power when demand exceeds generation.
- The peak load is supplied by the batteries.
- Depending on electrical loads, battery bank of 400 -1200 Ah battery bank (24V) is normal.
- AC power is available (via an inverter) whenever needed.



Fuel Gas Conditioning



- Concept is to get gas off a scrubber or casinghead with no free liquids, heat it, and keep it hot to the burner tip.
- Used micro heat exchanger and heat traced umbilical.

Generator Package

Enclosure contains the Stirling generator, the battery bank, the inverters, and the heat trace tank and pump.



Sucker Rod Application

- Installed in Feb. 2007 at RMOTC north of Casper, WY.
- Well produces about $\frac{1}{2}$ barrel/day of oil. The 3 HP (2.25 kW) motor runs about 15 minutes 4 times per day.
- As of May 2008 total operating hours are 3200.



SCADA Application

- Installed 2 units in Wamsutter, WY for about 200W
- As of May 2008, the units have 750 and 950 hours of run time.
- Fuel supply problems not related to the design.



Results

- One flame detection sensor was replaced after 1100 hours.
- Unit produces condensed water, up to 6 gallons (23 liters) per day.
- Maintenance interval for minor components is every 1000 hours. No plugs, filters or oil changes.
- The core engine requires service after approximately 5000 to 6000 hours. This involves replacement of Wobble yoke bearings, which is typically a half-day task.



Summary

- Stirling Cycle can be used in the oilfield.
- Viable option for combined power and heat where low maintenance is important.
- Properly install a good fuel gas supply design.



Acknowledgments; Questions?

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